NIAB TAG

Agronomy Strategy 2

2019-20

Autumn strategies

Winter cereals: autumn weed control, autumn pest control.
Winter beans: establishment, seed rates, weed control.

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Agronomy strategy 1:

Winter oilseed rape establishment, seed rates, seed treatments, sowing dates, weed control, disease control, autumn pest control.

Winter cereals: seed rates, sowing dates, seed treatments

Stubble cultivations for grass weed control.

Agronomy strategy 2:

Winter cereals: autumn weed control, autumn pest control.

Winter beans: establishment, seed rates, weed control.

Agronomy strategy 3:

Nitrogen, sulphur, growth regulators, spring weed control in cereals and break crops.

Agronomy strategy 4:

Cereals and break crops: fungicide strategies.

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Agronomy Strategy 2 2019-20

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Introduction

Once again we present our strategies for autumn agronomy of winter cereals and winter beans, based on our recent trials data. New trial information on rye-grass, bromes and black-grass is included and this influences our guidelines on agronomy for the coming autumn. These strategies will be updated as the autumn progresses in our Agronomy Updates and at our autumn Field Days, in response to weather conditions and crop growth patterns, and members can always discuss their own strategies with their Regional Agronomist.

As always we welcome any feedback, and we would like to wish our members every success with this coming autumn's agronomy.

NIAB TAG Regional Agronomy team

1. Black-grass control: winter wheat and winter barley

The best procedures for control of moderate-high black-grass populations

1. Grow another crop (spring cereal or season-long fallow).
2. Sow wheat after 15 October, or later if still considered feasible to produce a competitive crop.
3. Follow stubble management guidelines below. Apply at least one glyphosate spray before sowing, even if few black-grass plants have emerged.
4. Sow a robust seed rate (e.g. 400 seeds/m^2 for second half of October).
5. Where practicable within sowing date restraints, sow the crop when seedbed conditions allow a pre-emergence herbicide application (flufenacet-based stack, see options below) within 48 hours of drilling.
6. Tank mix this treatment (or better still follow a few days later – still pre-emergence) with glyphosate.

For low black-grass populations:

Follow options 2-5 above

Further discussion on these points follows.

1. Change rotation

If the anticipated black-grass population is high (more heads than wheat heads) or contribution from herbicide programmes is expected to be poor, **do not sow winter wheat**. A spring crop offers a much better option to maximise cultural control, with spring barley giving the best competitive canopy to smother black-grass resulting in much lower head numbers and hence seed return. Winter barley is less effective in this respect but will give better competition than wheat where the crop tillers well and early spring conditions produce a more competitive canopy.

2. Sowing date

- where the potential black-grass population is high (e.g. almost as many heads as wheat heads) – **sow from 15 October onwards**.
- where the potential black-grass population is moderate (e.g. less than 100 head/m^2 likely) – **sow from 7 October onwards**.
- where expected numbers are low, for example where the population is just starting to build, or where very good control was achieved in the previous crop, simply delaying until early October, provided establishment conditions are good, would still help considerably in keeping the population under control.

3. Stubble management

Stubble cultivation: this is done to prepare a good seedbed for black-grass seeds to encourage germination and emergence pre-drilling with a fine, rolled or pressed soil. However in dry conditions it would be better not to create one.

- **Wet harvest and/or post-harvest period** (such that soil has some moisture) – create a stale seedbed as soon as possible.
- **Dry harvest and post-harvest period** – soil is dry with no certainty of imminent wetting – leave stubble untouched for as long as practicable or until the soil is wetted again.

If a stale seedbed is created and black-grass emerges, spray off seedbeds with glyphosate before drilling even if there seems to be little black-grass emergence. This is more effective at killing seedlings than cultivations. Trials at our Black-grass Centre at Hardwick suggest glyphosate is best applied close to drilling (see Figure 1 on page 10) so if early sprays are necessary due to rapid green-up, repeat treatment closer to sowing the crop may be beneficial.

Ploughing is most effective when the vast majority of the viable seed is close to the soil surface and the plough buries these successfully. Often the best results are when the land is ploughed rotationally, after a few years of shallow non-inversion tillage; annual ploughing can be counter-productive.

4. Seed rate

Sow a robust seed rate. This does not need to be excessive but preferably at or slightly above the higher end of the ranges suggested in Agronomy Strategy 1. As a rough guide, for sowing early-mid October, consider 350-400 seeds/m^2 to give benefits in control. (There is little benefit in sowing above 400 seeds/m^2 at later sowing dates unless establishment is likely to be compromised by slugs or poor seed bed conditions.)

5. Herbicide options

Herbicides – wheat

1. Pre-emergence

Avadex Excel: if soils have reasonable moisture, the following mixes (other than Avadex Factor mixes) can be shortly followed by Avadex Excel, but note Avadex Excel (and Avadex Factor) should still be applied pre-emergence.

If soils are dry, however, start with Avadex Excel and follow with one of the options below.

For optimum performance, apply these treatments to a good seedbed with a moist soil surface if possible. Ensure appropriate seed depth when sowing.

(i) Moderate-high populations: 3-4 way mixes

a) **Liberator** 0.3 l/ha + **Crystal** 2.0 l/ha + **Hurricane** 0.18 l/ha + either **Defy** 3.0-4.0 l/ha* or **Avadex Factor** 3.6 l/ha

b) **Liberator** 0.6 l/ha + **Hurricane** 0.12 l/ha, + **Defy** 3.0-4.0 l/ha*, **pendimethalin** 1,000 g/ha or **Avadex Factor** 3.6 l/ha

c) **Crystal** 4.0 l/ha + **Hurricane** 0.24 l/ha, + *either* **Defy** 3.0-4.0 l/ha* or + **Avadex Factor** 3.6 l/ha

*Check with manufacturer for appropriate doses for peri-emergence treatment.

(ii) Low populations, where good control from post-emergence treatments is expected:

(a) Liberator 0.6 l/ha (± 0.12 l/ha Hurricane)

or

(b) Crystal 4.0 l/ha (+ up to 0.24 l/ha Hurricane)

or

(c) Liberator 0.3 l/ha + **Crystal** 2.0 l/ha (+ up to 0.18 l/ha Hurricane)

With low target populations these could be applied peri-emergence if required.

Low populations may also give the opportunity to 'protect' flufenacet, i.e. avoid its over-use, e.g.

Defy 4.0-5.0 l/ha (or **pendimethalin** 1,000-1,200 g/ha) + **Hurricane** 0.1-0.2 l/ha + **Avadex Factor** 3.6 l/ha

See following comments concerning straight flufenacet products.

2. Post emergence

(i) **Further residual herbicide mix** i.e. any of the flufenacet-based options in (1. pre-emergence) not already applied (but not Avadex Excel/Factor). This approach would be particularly appropriate where little is expected from an ALS-based post-emergence treatment, though it does leave the option of applying such in spring if further treatment is needed. Note the four-way stacks mentioned previously as pre-emergence options can be split into two residual applications in this way provided these are close together (see Figure 2 on page 10) and doses are kept fairly robust. Apply 2-3 weeks after the pre-emergence treatment: do not wait for a particular weed growth stage. However, across the two fairly close timings, this amount of chemical on an emerging crop is fairly heavy so do not mix any other sprays (e.g. insecticides) with the second treatment (see comment below).

Note: the maximum advised doses of flufenacet and other actives are given below.

(ii) **ALS-based treatment:** (assumes these have been effective in the recent past). Weather conditions should be conducive to weed growth, target foliage should be dry and care should be taken to select the best spray technique (nozzles, forward speed etc). Apply at 1-2 leaf stage of weed.

Atlantis OD (1.2 l/ha) or **Hamlet** (1.5 l/ha), all with appropriate adjuvant

Apply in autumn/early winter, when the majority of black-grass has 1-2 leaves (see timing comments below). Hamlet contains diflufenican: the season-long dose should not exceed 125 g/ha of active ingredient. Liberator also contains diflufenican.

Add:

1. **flufenacet** 120 g a.i./ha, e.g. Liberator (0.3 l/ha) or Firebird (0.3 l/ha) or other product delivering the same flufenacet dose.

or

2. **pendimethalin** (e.g. Stomp 400 2.5 l/ha, or 2.0 l/ha where 4.0 l/ha Crystal applied previously, noting 2,000 g a.i./ha limit).

or

3. **Auxiliary** 3.0 l/ha

If using Liberator for a second time, and the total dose will be brought above 0.6 l/ha, a minimum interval of six weeks between applications should be observed.

Pre/peri-emergence timings and sequences

- All residual herbicides (with the possible exception of Avadex) are best applied to a moist and fine seedbed surface, even if the surface may dry out within a few hours. However, it is advisable to delay the application where the seedbed is so dry as to prevent black-grass germination.
- Both pre- and peri-emergence stacks can sometimes result in crop damage but NIAB TAG trials show that provided there is no loss of wheat plants there is no impact on yield. As mentioned above, with the loss of Deter seed treatment growers may be tempted to apply a pyrethroid as soon as the crop emerges. If mixed with a peri-emergence spray (as a first or second treatment) then crop damage may be more likely. More importantly, this is not the best time to target aphids with respect to the T-sum system described in Section 8 so the treatment could be wasted.
- With this in mind, always check label requirements for crop seed depth and seedbed quality with the pre-/peri-emergence products.

Pre-emergence: key points

- **Flufenacet:** any programme should be based on flufenacet. NIAB TAG trials suggest a good uplift from applying a total of 360 g/ha (maximum of 240 g/ha in a single application; i.e. that in the full dose of Liberator or Crystal). There is a further but much smaller increase in control from applying 480 g/ha, and care should be taken with this higher dose, on light or gravelly soils in particular.
- Straight flufenacet products (System 50, Fence, Sunfire etc) allow flexibility in flufenacet dose but growers should be aware that these products should still be applied with a black-grass active partner if targeting this weed. **Reduced sensitivity to flufenacet** has been detected in Europe so we must protect the molecule with effective partner products.
- There is also evidence of flufenacet appearing in some watercourses so be careful with applications, particularly if using later in the autumn.
- The total dose of flufenacet should also not exceed 240 g/ha in a single application, so do not, for example, add more flufenacet to a full dose of either Crystal or Liberator. However they could be used in a follow-up treatment, provided the total dose applied to the crop does not exceed 360 g/ha.
- **Dry seedbeds:** the activity of flufenacet and diflufenican are most compromised by application to a dry soil surface (i.e. the top 2 cm), particularly if it remains dry for some time after application. The impact of such a dry seedbed is less for control with Defy, even less for pendimethalin and least of all for tri-allate.
- **Defy** performs better applied peri-emergence than pre-emergence though if applied pre-emergence in a flufenacet-based stack it is still one of the stronger partners for such mixes.
- **Diflufenican** is cheap (available alone and pre-mixed in e.g. Liberator) and can provide some additional control to flufenacet-based products (Liberator, Crystal), particularly in moist conditions. **Pendimethalin** requires a fine seedbed but is less affected by dry seedbeds. In years when dry seedbeds prevail, Crystal has tended to give higher levels of control than Liberator. However any tank-mix involving **flufenacet**, **diflufenican** and **pendimethalin** can provide a good base to a programme (unless high levels of resistance to pendimethalin are suspected).
- Note that some formulations of diflufenican now have 12 metre aquatic buffer zone requirement and some formulations of pendimethalin have 20 metre zones. Check the product label or ActivSmart for this information.
- **Pendimethalin:** the EC formulation is the most effective on black-grass. It is the cheapest formulation but it can stain equipment.
- Be aware of maximum doses (advised or obligatory) both at individual timings and also for the season:

Table 1. Total dose limits for grass-weed herbicides (advisory or statutory)

	Total dose per season	Dose per timing	Comments
Flufenacet	480 g/ha	240 g/ha	This may still be too high on lighter and/or gravelly soils. There is a maximum total dose of 240 g/ha or 360 g/ha for an individual product
Diflufenican	125 g/ha		Particularly where next crop will be a broad-leaved crop
Pendimethalin	2,000 g/ha	1,320 g/ha	

Application technique

Spray water volumes

- In NIAB TAG trials, applying some pre-emergence herbicides in a water volume of 100 l/ha has been at least as effective as 200 l/ha but check whether the product(s) chosen can be applied at this volume of application. Occasionally higher water volumes are more effective but this is not a consistent effect and has to be considered alongside time taken to cover the acreage required. Any extra control benefits will be lost if some of the crop cannot be treated in autumn.

Drift reduction

- With pre-emergence treatments the target is not difficult to hit but there is more scope for spray drift than there would be if an emerged crop were being treated. Drift reduction measures are particularly important not only to avoid contamination of the wider environment but also to avoid loss of active ingredient and suffering poorer herbicide performance as a result. This latter point may not be considered significant compared to effects on the environment but we currently strive for every last percentage point of control and so we need to take account of this. Forward speed and boom height are both factors which influence drift and these should be minimised as far as is practical given the timeliness required of these tasks.
- On heavy soils control has been more reliable when **angled jets** were used, presumably due to better coverage of three-dimensional (i.e. cloddy) seedbeds. On level fine seedbeds the advantages seen in these may not be as apparent.

Post-emergence (wheat) – Key points

- Such is the variability of ALS-inhibitor products against black-grass that growers should not put too much reliance on them and put emphasis on earlier residual treatments.
- Products such as Atlantis can still follow these programmes, but although these may delay the resurgence of survivors, we are still seeing the optimum timing for Atlantis, for example, as autumn rather than spring.

Herbicides – barley

1. Pre-emergence

Pre-emergence treatment is by far the most effective timing for this crop, hence the comments in the wheat section concerning conditions for residual herbicides apply to a greater extent. However, level of input needs to be moderated to avoid adverse crop effects which would compromise the competitive ability of the crop, though by the same logic this more-competitive crop should not require such high input as is applied to wheat.

Many of the pre-emergence options are not supported at peri-emergence by the respective manufacturers, further narrowing the application window. Use at peri-emergence should therefore be considered a 'grower's risk' decision.

- Treatment options are:

  a) Crystal 4.0 l/ha + **Defy** 2.0-4.0 l/ha (2.0 l/ha if peri- or post-emergence)

  b) Crystal 2.0 l/ha + **Liberator** 0.3 l/ha

  c) Liberator 0.6 l/ha + **pendimethalin** 1,000-1,200 g/ha
- Ensure **good seedbed quality** and **correct minimum seed depth** particularly with the higher doses.
- For stronger activity consider further stacking with Avadex (pre-emergence). Diflufenican or pendimethalin can also be components of barley stacks however, as discussed above, avoid more than two products in the same spray tank, to minimise effects on crop vigour and competitive ability.
- For relatively low populations, another option would be:

  Defy 4.0 l/ha + Avadex Factor 3.6 l/ha (pre-emergence only).

2. Post emergence

Post-emergence treatment will not give acceptable control unless following a pre-emergence treatment.

a) Liberator (0.3 l/ha) or another product applied at a dose to deliver 120 g a.i./ha flufenacet.

Apply at the 1 (-2) leaf stage of black-grass.

If using Liberator for a second time and the total dose will be brought above 0.6 l/ha, a minimum interval of six weeks between applications should be observed. Check label for more details. Again, take care with the season-long dose of diflufenican.

Table 1. Pre-emergence product performance (winter wheat), 2018

These figures give the percentage control of black-grass heads at three sites in 2018.

Levels of control are not high but these were pre-emergence only, not followed by further treatments.

	Pre-em	**Peri-em**	**% control** (reduction in heads/m^2)		
			Cambridge	**Norfolk**	**Lincs**
1	System 50 0.48 l/ha		56	30	31
2	Liberator 0.6 l/ha		53	38	46
3	Crystal 4.0 l/ha		88	32	46
4	Avadex Excel 15 kg/ha		74	4	46
5	Liberator 0.6 l/ha + Defy 4.0 l/ha		90	45	32
6		Liberator 0.6 l/ha	46	19	61
7	Pontos 1.0 l/ha		69	56	49
8		Pontos 1.0 l/ha	40	41	38
	Black-grass heads/m^2 in untreated		*422*	*311*	*231*

Flufenacet alone (Treatment 1) gave poorer control than the formulated products but was not far behind these. Avadex Excel reflected its general performance recently giving good levels of control at two sites, but was poor at the Norfolk site, indicating some degree of variability. Treatments 2 and 6 show a better performance from Liberator applied pre- rather than peri-emergence, though again this was not consistent with one site showing the reverse trend. Pontos (flufenacet plus picolinafen) was more consistent in this respect, performing better at all sites when applied pre-emergence. Recent comparisons between Crystal and Liberator have shown a better performance overall from the former, though in this trial series this trend was only seen at one of the three sites (Treatments 2 and 3).

The highest level of control seen in the trial series above came from a programme with no ALS-inhibitor products. Post-emergence treatment with these has been declining in efficacy for some time (though still very effective on some farms, particularly those with longer rotations) and for many the preferred second treatment is a further residual mix. Figure 2 overleaf stresses the importance of early timing with such an approach, the points showing the level of black-grass control from various timings of a second residual stack following a pre-emergence one.

Figure 1. Effect of pre-drilling and pre-emergence glyphosate, Cambridge 2019

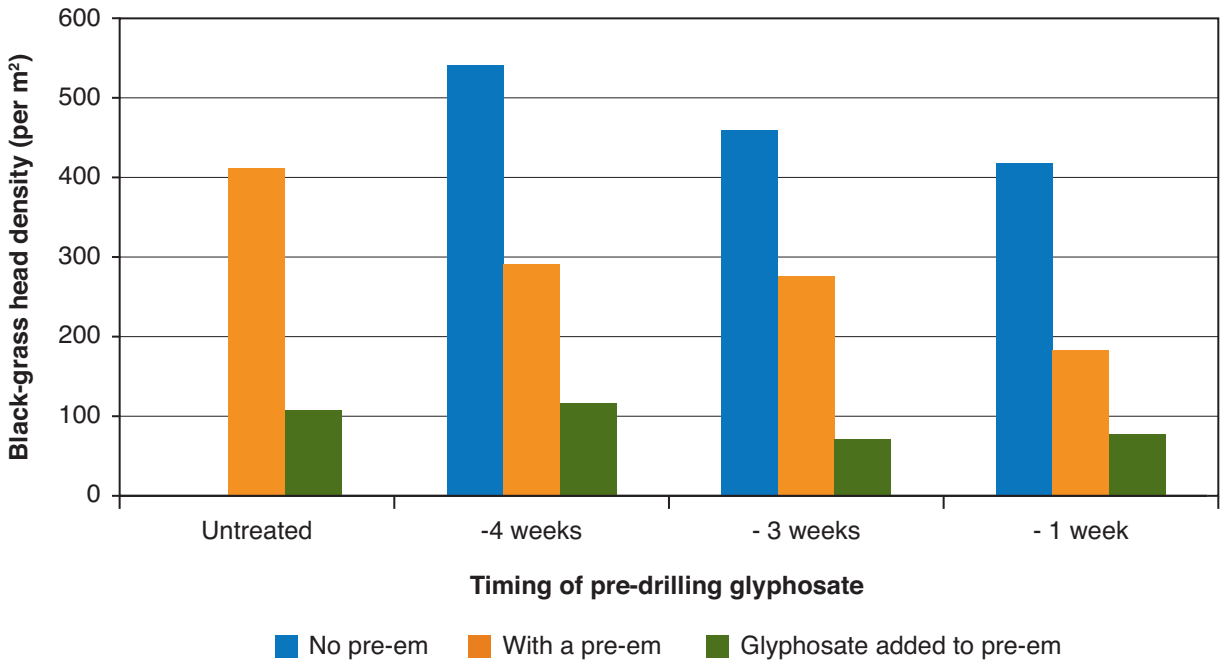
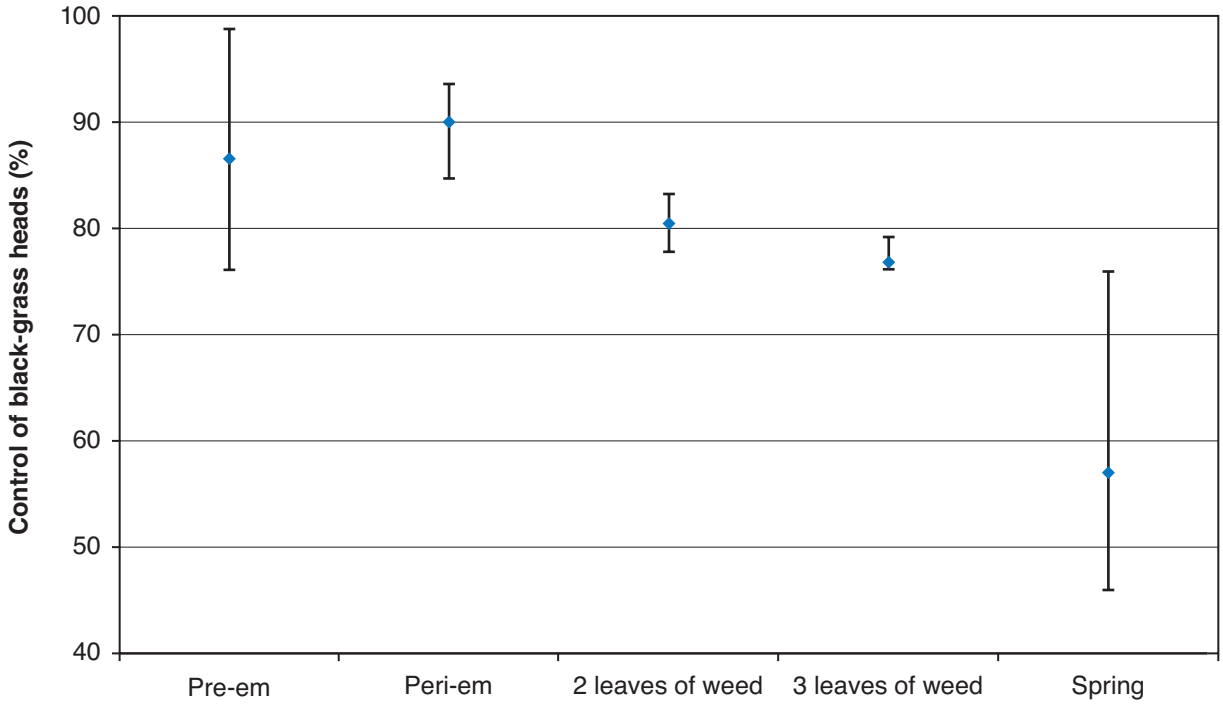


Figure 2. Timing of a second residual application (mean of three sites, winter wheat), 2018



The first treatment ('Pre-em') received Crystal 4.0 l/ha + Liberator 0.6 l/ha+ Hurricane 0.2 l/ha + Defy 3.0 l/ha in one pre-emergence application. Subsequent treatments received the Crystal + Hurricane pre-emergence followed by Liberator + Defy at various timings from peri-emergence to spring. Splitting pre-and peri- gave the overall best control, better than all products applied pre-emergence, but once the second timing was delayed beyond peri-emergence, control fell away.

A similar trial in 2019 excluded the last two timings and percentage control figures were more variable (up to 90% at one site). Nevertheless the 'pre-peri' treatment was at least as effective as the 'all pre-em' treatment and showed least variation across the two sites. Again, delaying the second application to the two-leaf stage of the weed gave poorer control.

The benefit of glyphosate treatment, applied with the pre-emergence herbicide or as a pre-drilling treatment, is shown in Figure 1.

The orange bars show there is a benefit of pre-drilling glyphosate but there is a strong trend towards increasing black-grass numbers with longer gaps between pre-drilling glyphosate and drilling date whether a pre-emergence herbicide is applied or not (blue and orange bars). However when glyphosate is also added to the pre-emergence herbicide (green bars) this effect levels off considerably, so this approach possibly allows more flexibility in timing of stale seedbed sprays.

Active ingredients of products listed

Product	Active ingredients	Concentration	Also available as (e.g.)
Atlantis OD	iodosulfuron-methyl + mesosulfuron-methyl	2 g/l + 10 g/l	Horus, Hatra; Niantic (6 g/kg + 30 g/kg)
Auxiliary	clodinafop-propargyl and prosulfocarb	10 g/l + 800 g/l	Grapple
Avadex Excel	tri-allate	150 g/kg	–
Avadex Factor	tri-allate	450 g/l	––
Crystal	flufenacet + pendimethalin	60 g/l + 300 g/l	Trooper, Rock, Shooter
Defy	prosulfocarb	800 g/l	Fidox, Jade
Firebird	flufenacet + diflufenican	400 g/l + 200 g/l	Liberator, Regatta, (both 400 g/l + 100 g/l), Herold
Hamlet	iodosulfuron-methyl + mesosulfuron-methyl + diflufenican	2.5 g/l + 7.5 g/l + 50 g/l	–
Hurricane	diflufenican	500 g/l	Twister, Goshawk, Turnpike
Liberator	flufenacet + diflufenican	400 g/l + 100 g/l	*see* Firebird
Pontos	flufenacet + picolinafen	240 g/l + 100 g/l	Quirinus, Kudu, Lantern (N.B. picolinafen dose varies)
Stomp	pendimethalin	400 g/l	Stomp Aqua (455 g/l), Anthem, Pendragon
System 50	flufenacet	500 g/l	Fence, Gorgon (both 480 g/l); Sunfire, Iconic

- **Please check** if using an alternative product that it is approved for the crop concerned. Different products with identical formulations do not always have the same approved crops list. This is particularly pertinent to EAMUs.
- Inclusion of an alternative product in this list does not represent an endorsement of that product, nor does it imply that products not included in that list are inferior.
- Please check also for levels of active ingredients. Although some of the differences have been highlighted where appropriate, members should still check a.i. levels as differences could clearly lead to different levels of efficacy if used at the same product doses recommended in the particular Strategy.

2. Brome control

1. Sterile brome or great brome

Pre-drilling

- Ploughing is still an effective way of controlling all bromes, more so than with any other grass-weed. It is more effective than even the most successful non-inversion approach.
- Where not ploughing, shallow-cultivate stubbles **no deeper than 5 cm** immediately after harvest to encourage germination prior to spraying-off. Leaving seeds on the surface can induce dormancy, reducing the chances of emergence and hence control prior to drilling.
  Note: the comments on dry stale seedbeds in the black-grass discussion may also apply to bromes, however the dormancy issue is the overriding factor hence stubbles should be cultivated even if the soil is dry.
- Higher crop plant populations will help to suppress brome in the early stages and hence reduce final head number.

Herbicides – winter wheat

Pre-emergence

- For moderate-high populations apply

  Liberator 0.6 l/ha pre-emergence ***and*** **Avadex Excel** 15 kg/ha,

  or **Liberator** 0.6 l/ha + **pendimethalin** (1,000-1,200 g/ha)

  or **Crystal** 4.0 l/ha + **Hurricane** 0.2 l/ha
- For lower populations use Avadex (*or* Crystal or Liberator) as above.

Post-emergence – from the 2-leaf stage of the weed

- **Broadway Star** 0.265 kg/ha,

or

- **Atlantis* OD** 1.2 l/ha **plus *either***

(i) Liberator 0.3 l/ha (at least six weeks after pre-emergence Liberator) ***or***

(ii) diflufenican, e.g. Hurricane 0.2 l/ha (or 0.1 l/ha where Liberator used pre-emergence).

*Hamlet, formulated with diflufenican, would be expected to have good activity against bromes. (See page 13 re total diflufenican dose).

Apply post-emergence treatments **in autumn** when the brome population has recovered from pre-emergence treatment, from the two leaf stage of the weed.

Weather conditions should be conducive to weed growth, target foliage should be dry and care should be taken to select the best spray technique (nozzles, forward speed etc).

Monolith is also an option being an effective spring-applied formulation of mesosulfuron-methyl and propzycarbazone-sodium (see trial data on page 14).

2. Meadow brome, soft brome or rye brome

Pre-drilling

- As with other brome species, ploughing is the most effective cultivation technique.
- If not ploughing, **leave stubbles uncultivated** for at least a month after harvest – early cultivation will delay the breaking of dormancy in these brome species, making effective herbicide timing in the subsequent crop difficult.
- In wheat, where there is a mixture of brome species cultivate according to relative numbers of each species.

Herbicides

- These species are slightly easier to control than sterile or great brome.
- **Broadway Star**, **Atlantis**, (see Hamlet comment on page 12) **Monolith**, **Pacifica Plus**, **Monitor** and **Attribut** all have good activity against these species when **applied in spring**, during active growth but before stem extension of the weed.
- In NIAB TAG trials, spring treatments as described have often given high levels of control of meadow brome without the aid of a pre-emergence spray. In trials, Broadway Star has also given good control of rye brome when applied in spring.

Winter barley herbicide programmes (all species)

- Pre-emergence: Liberator **and/or** Avadex as above, followed by:
- Liberator 0.3 l/ha (at least six weeks after pre-emergence Liberator if used).
- The strongest post-emergence brome products: Broadway Star, Atlantis, Pacifica Plus, Monolith, Monitor and Attribut **cannot be used on barley**. Hence, pre-emergence treatment is very important; nevertheless effective control of any brome species may still not be possible.

- Atlantis, Hamlet, and Broadway Star should be applied (to wheat only) in autumn for **sterile** or **great brome** control (NIAB TAG trials have shown better control from autumn treatment, see trial data below), though as with other grasses environmental conditions affecting weed emergence, growth and hence herbicide susceptibility, will be overriding factors.
- **Meadow** and **soft brome** have been more common in crops in recent seasons. Both are likely to have a more protracted emergence so treatment may be more effective in spring, provided good growing conditions prevail.
- Care should be taken with diflufenican dose post-emergence where it has been used pre-emergence. Total doses above 125 g/ha should be avoided. Liberator followed by Hurricane at 0.1 l/ha as above, for example, delivers 110 g diflufenican/ha, and 90 g/ha in total with 0.3 l/ha Liberator post-emergence. Hamlet also contains diflufenican.
- Cultural control: the effects of plant population, and of growing winter barley rather than winter wheat, are similar to those seen in black-grass. Barley is the more competitive against bromes also, and crop competition can play a useful part. Note however the more restricted herbicide range for barley as described above.

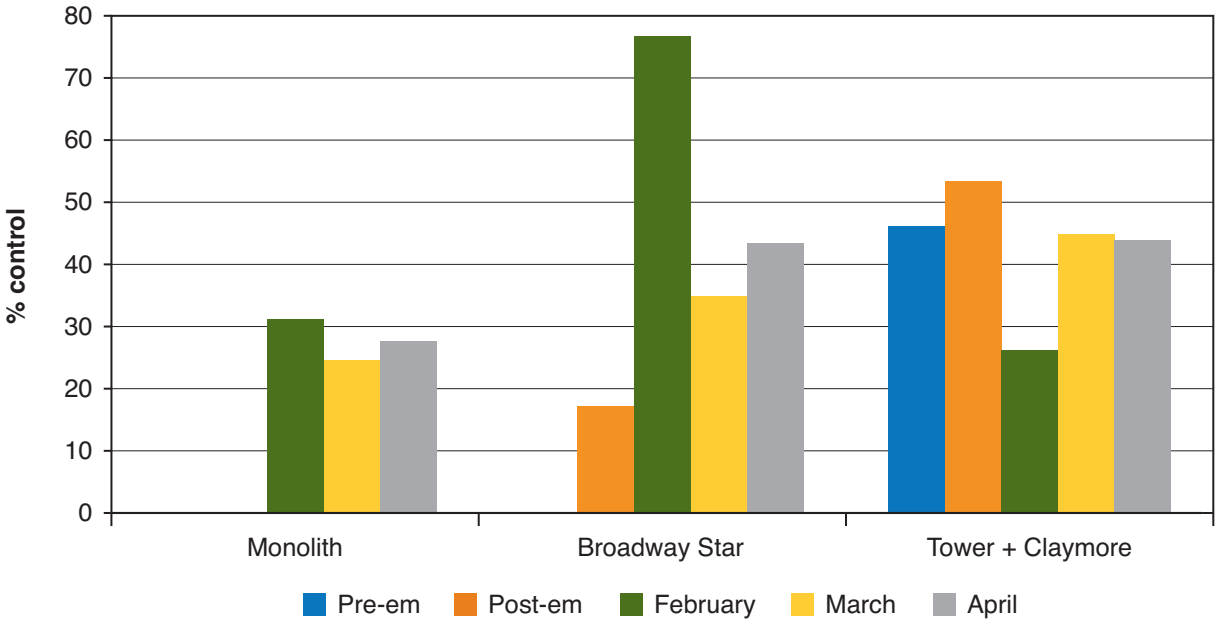
Rye brome control programmes

In 2019 a trial was carried out to review performance of rye brome (*bromus secalinus*) herbicide programmes in winter wheat and to explore contrasting control strategies. Overall the maximum level of control of heads was ~77% (with only three treatments achieving over 70% control) reflecting how difficult this weed can be to control effectively even with relatively high herbicide input.

The optimum timing of an ALS-inhibitor (Broadway Star) was in the spring, not the autumn and was early in the spring (11 February). Autumn-applied residual herbicides could achieve a certain level of control (up to ~50%) but a spring applied ALS-inhibitor follow-up was required to provide maximum control.

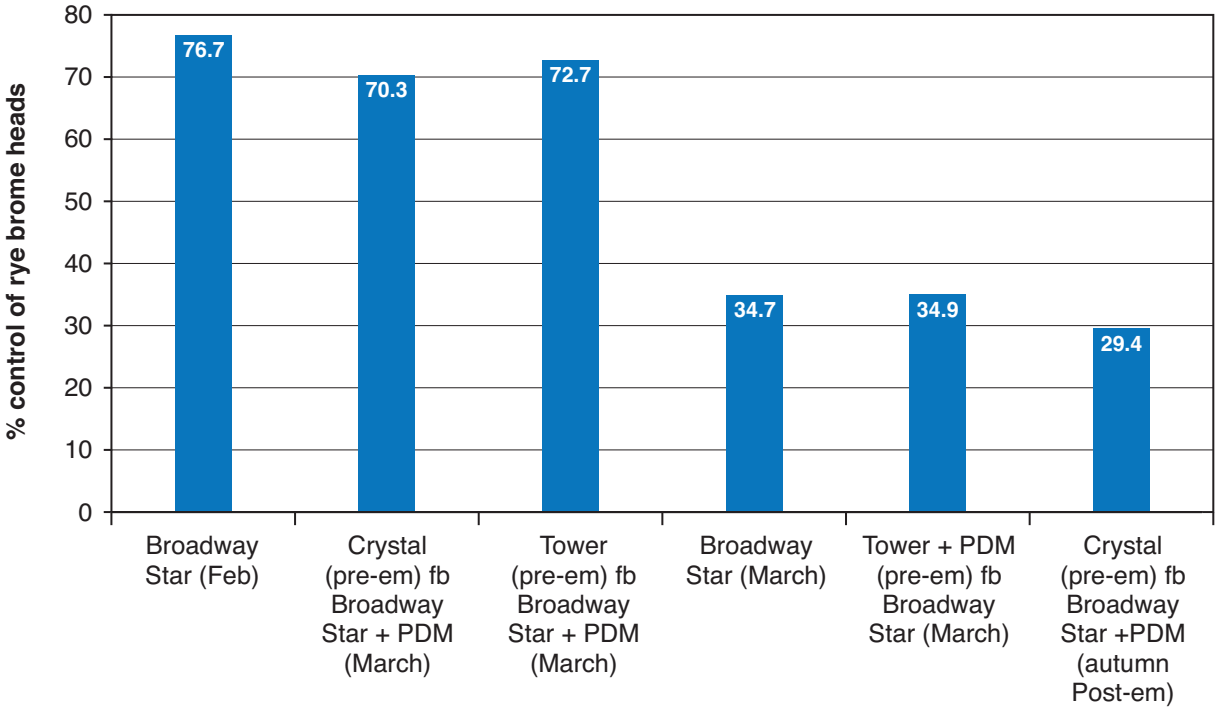
The largest single factor in determining success was optimisation of the timing of the ALS-inhibitor element of the programme (in this case Broadway Star) but the negative effect of applying this product at a suboptimal timing could be largely mitigated by tank mixing with pendimethalin.

Figure 3. Application timing and control across three herbicide treatments



In the 2018/19 trial it seems that conditions early in the spring (February) encouraged good herbicide activity while weeds were still relatively small. In other seasons it is likely that the optimum timing would be later (because of a lack of active weed growth at this early timing).

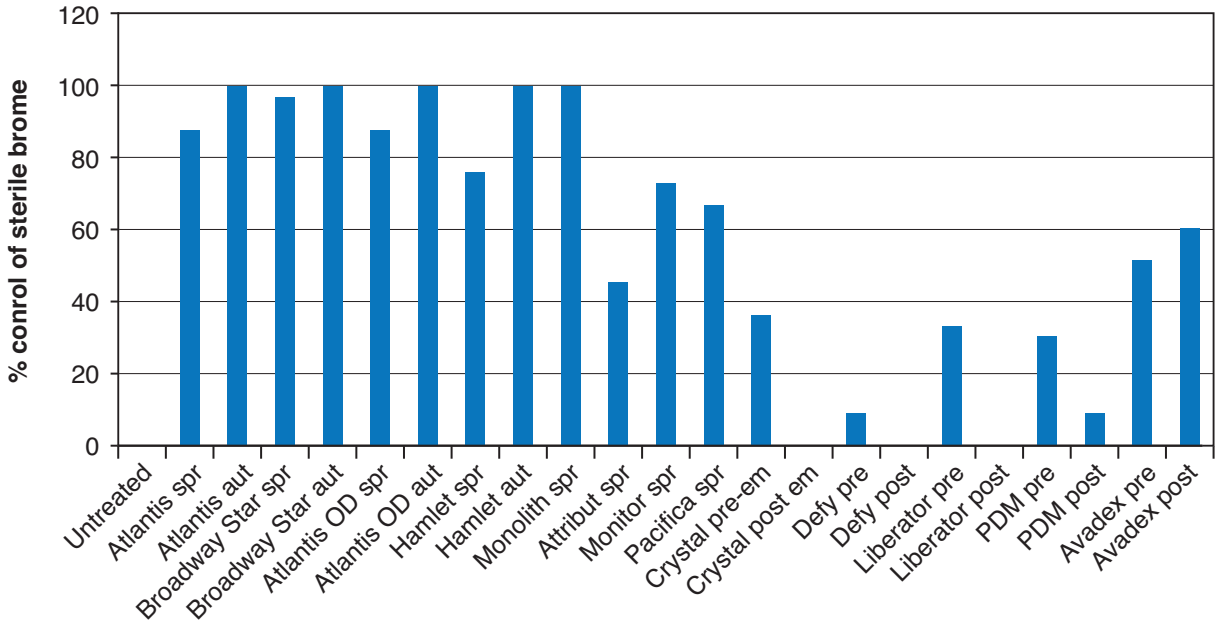
Figure 4. Percentage control of heads from different Broadway Star based programmes



This trial showed that Broadway Star applied in February was the most effective way to achieve control of rye brome heads. This may not be the same case every season as the optimum timing is likely to change dependent on conditions for active growth of the weed. What this trial does perhaps demonstrate is that optimising the application timing of the key herbicide is the most important factor and that increasing the herbicide input level cannot compensate for a poorly timed application.

In terms of the programmes, approaches that mixed chemistry in their sequences were more effective when compared with treatments that used a sequence of the same chemistry (i.e. the Tower v Crystal programmes).

Figure 5. Sterile brome control programmes, Kent 2018



This trial involved sown seed so is not fully representative of a field situation. However, there are useful trends here with Atlantis (WG and OD), Broadway Star and Hamlet all giving good control but better from autumn application, a trend seen consistently in other NIAB TAG trials. Monolith was only applied in spring but gave 100% control. Attribut, Monitor and Pacifica (all spring applied) were less effective. Crystal, PDM, Avadex and Liberator all gave useful levels of control (pre-em rather than post-em) and would contribute to a programme; Avadex was the more effective product in this group.

Active ingredients of products listed

Product	Active ingredients	Concentration	Also available as (e.g.)
Atlantis OD	iodosulfuron-methyl + mesosulfuron-methyl	2 g/l + 10 g/l	Horus, Hatra; Niantic (6 g/kg + 30 g/kg)
Attribut	propoxycarbazone-sodium	700 g/kg	–
Avadex Excel	triallate	156 g/kg	–
Broadway Star	pyroxsulam + florasulam	70.8 g/kg + 14.2 g/kg	–
Hamlet	iodosulfuron-methyl + mesosulfuron-methyl + diflufenican	2.5 g/l + 7.5 g/l + 50 g/l	–
Liberator	flufenacet + diflufenican	400 g/l + 100 g/l	Regatta
Hurricane	diflufenican	500 g/l	Twister, Goshawk, Sempra
Monitor	sulfosulfuron	800 g/kg	–
Pacifica Plus	iodosulfuron-methyl + mesosulfuron-methyl + amidosulfuron	10 g/kg + 30 g/kg + 50 g/kg	–

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- Inclusion of an alternative product in this list does not represent an endorsement of that product, nor does it imply that products not included in that list are inferior.
- Please check also for levels of active ingredients. Although some of the differences have been highlighted where appropriate, members should still check a.i. levels as differences could clearly lead to different levels of efficacy if used at the same rates recommended in the particular Strategy.

3. Italian rye-grass control

Pre-drilling

- **Stale seedbeds** sprayed off with glyphosate may have some benefit but may not give high levels of control since the germination period is prolonged, more so than in black-grass for example. Nevertheless for difficult-to-control populations, cultural control is more important than for black-grass (see below).
- **Ploughing** is still an effective cultivation technique but where populations are high and difficult to control its effects can be marginal.

Herbicides

The following herbicide programmes will be appropriate for both **winter wheat** and **winter barley**, with the **exception** of the ALS-inhibitor herbicides such as Atlantis, Hamlet, Pacifica Plus, Broadway Star, and Auxiliary which cannot be used on barley.

There are still two clearly distinct types of rye-grass population and this dictates the level of herbicide input required. For the more difficult populations, programmes and expenditure are similar to those required for black-grass control (where both weeds are targeted, follow the black-grass control programmes in Section 1).

1. 'Difficult to control' populations

(i) Apply a **pre-emergence treatment** of

- **Defy** 3.0-4.0 l/ha + **Crystal** 4.0 l/ha: consider **Avadex Excel** also.

(ii) **Followed by** at the 1-2 leaf stage of rye-grass:

a) **Broadway Star** 0.265 kg/ha + *either* **Hurricane** 0.24 l/ha *or* **pendimethalin**, e.g. Stomp 400 2.5 l/ha, or 2.0 l/ha where 4.0 l/ha Crystal applied previously.

or

b) **Atlantis OD** 1.2 l/ha + **pendimethalin**, e.g. Stomp 400 (2.5 l/ha, or 2.0 l/ha where 4.0 l/ha Crystal applied previously).

Hamlet at 1.5 l/ha is another post-emergence option, its diflufenican content suggesting less benefit from adding a partner. (Check total diflufenican dose if Liberator used at pre-emergence.)

(iii) If further treatment is necessary later, **Axial Pro** can be used.

2. 'Easier to control' populations

- **Where numbers are high**, pre-emergence treatment is still important:
- **Crystal** 3.0 l/ha

or

- **Defy** 3.0 l/ha

or

- **Tower** 2.0 l/ha + **pendimethalin** 700 g/ha.

The latter two options offer a non-flufenacet route, given that insensitivity to this active in rye-grass has been detected in the UK. Tower + PDM has worked well early post-emergence (see below) but note we have no information to date on CTU + PDM on difficult populations.

Apply to a fine consolidated seedbed.

Follow with **Broadway Star** or **Atlantis** as above for difficult populations.

Alternatively consider **Axial Pro** when the most advanced rye-grass is at the 2-3 leaf stage. Add pendimethalin, e.g. 2.5 l/ha Stomp 400 to Axial Pro where a pre-emergence herbicide has not been applied. Axial Pro is an ACC-ase product and will not be effective if there is resistance present to this mode of action.

- **Where populations are low**, consider the post-emergence options only.
- It is important to know your rye-grass population. In our trials we have regularly seen ranges of control of 95-100% across all treatments and in other trials 37-100%. There are now some field stocks that cannot be controlled reliably with herbicides and additional cultural control measures are essential.

Cultural control

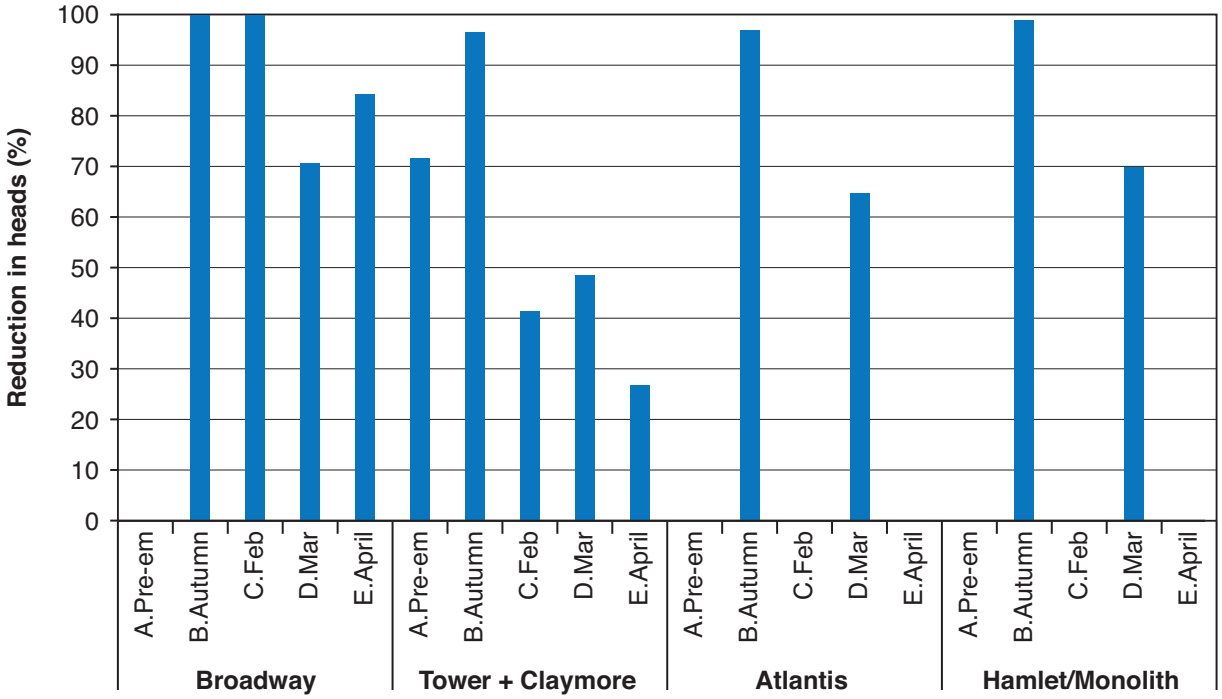
As stated above, this is very important for **difficult rye-grass**:

- Robust seed rate (Agronomy Strategy 1)
- Delayed sowing
- Stale seedbeds as discussed above
- Target the weed elsewhere in the rotation (with alternative modes of action)
- Spring cropping is not always as effective as for black-grass but still worth considering where weed numbers are high; in extreme cases options such as fallow or maize may need to be considered.
- **Pre-emergence timing**: as with black-grass (see Section 1) pre-emergence herbicides should be applied within 48 hours of drilling for best effect but if delayed, **glyphosate** can be a useful addition for any rye-grass plants that have started to emerge.

- As with other grass-weeds ploughing may bring up seed, particularly if high seed numbers have been ploughed down in recent seasons; this is unlikely to have a negative impact if seed shed this year has been high anyway, but will be more significant for a currently low population. Hence rotational ploughing may be more effective.
- In other NIAB TAG trials on herbicide-resistant rye-grass pre-emergence treatments used alone have given higher control figures than post-emergence alone; hence pre-emergence treatment is an important part of the programme.
- **Broadway Star** (wheat only) has performed as well as Atlantis in NIAB TAG rye-grass trials. It does, however, have a wider broad-leaved weed spectrum.
- **Auxiliary** also has good activity against rye-grass.
- Do not exceed a total dose for an individual crop of 125 g/ha of diflufenican or 2,000 g/ha of pendimethalin. The maximum dose of pendimethalin per application is 1,320 g/ha.
- See discussion on application technique for residual herbicides in Section 1.

Trials using sown seed of susceptible (easier to control) Italian rye-grass were continued at our Kent Centre. Whilst this is not fully representative of a field population, it gave useful comparisons of products and timings:

Figure 6. Autumn and spring treatment of IRG, East Malling 2019

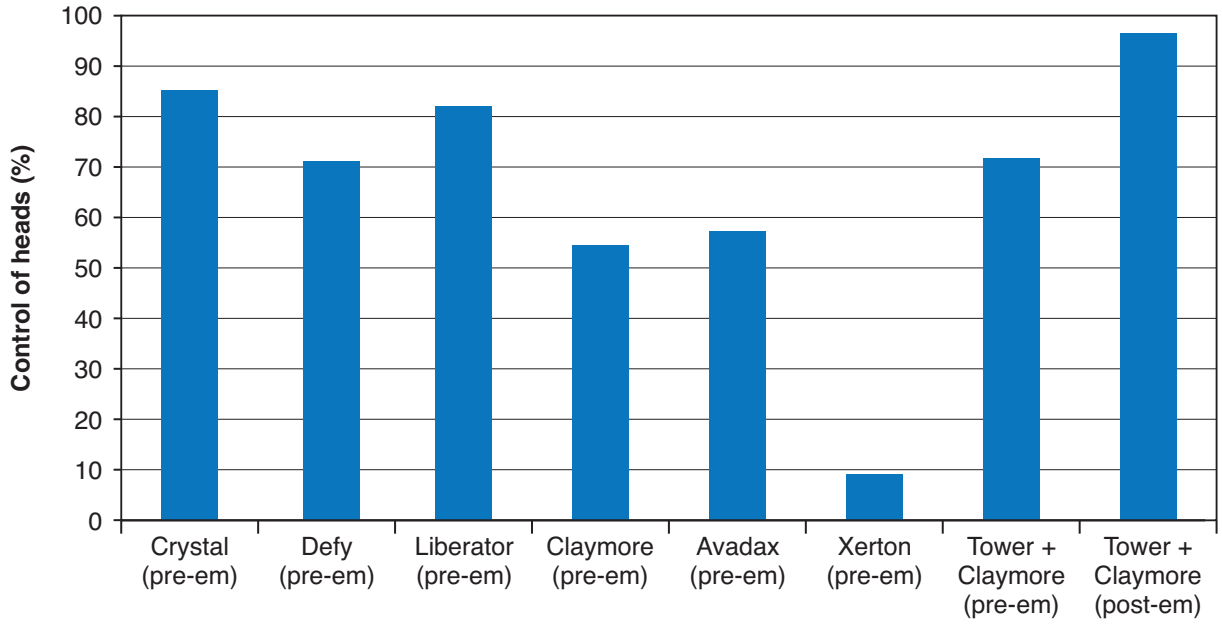


Weed population in untreated: 50 plants/m^2 (December). Trial sown 28 September.
Treatment timings: 1 October (pre-em), 6 November, 13 February, 18 March, 12 April.

As seen in the 2018 trial, with this 'easy to control' population many treatments gave nearly 100% control. The approach of using Tower + pendimethalin to provide three actives (PDM, DFF and CTU) in a single application appears to be an effective approach and for this mixture a post-emergence timing gave slightly better control. Atlantis, Hamlet and Monolith gave comparable control to Broadway Star if applied in autumn, however all these products gave poor control when treatment was delayed to March. Broadway Star still gave good control in February though other ALS-inhibitor products were not applied at this timing.

Again, on a sown, susceptible rye-grass population, the following residual treatments were applied with no follow-up.

Figure 7. Residual herbicide control of Italian rye-grass, Kent 2019



The CTU + PDM treatment (Tower + Claymore) performed well, particularly as a post-emergence treatment and this may be useful in future as a non-flufenacet option. Defy (at 5 l/ha) gave useful control but was not quite as effective as Crystal or Liberator. However in another trial, where these residuals are in a programme (followed by Broadway Star), there was no difference between these three products. Xerton (ethofumesate) was fairly ineffective against this weed.

Active ingredients of products listed

Product	Active ingredients	Concentration	Also available as (e.g.)
Atlantis OD	iodosulfuron-methyl + mesosulfuron-methyl	2 g/l + 10 g/l	Horus, Hatra; Niantic (6 g/kg + 30 g/kg)
Auxiliary	clodinafop-propargyl and prosulfocarb	10 g/l + 800 g/l	–
Avadex Excel	tri-allate	150 g/kg	–
Axial Pro	pinoxaden	55 g/l	–
Broadway Star	pyroxsulam + florasulam	70.8 g/kg + 14.2 g/kg	–
Crystal	flufenacet + pendimethalin	60 g/l + 300 g/l	Trooper, Rock, Shooter
Defy	prosulfocarb	800 g/l	Elude, Jade
Hamlet	iodosulfuron-methyl + mesosulfuron-methyl + diflufenican	2.5 g/l + 7.5 g/l + 50 g/l	–
Liberator	flufenacet + diflufenican	400 g/l + 100 g/l	Regatta
Monolith	mesosulfuron-methyl and propoxycarbazone-sodium	45 g/kg + 67.5 g/kg	–
Stomp	pendimethalin	400 g/l	Stomp Aqua (455 g/l), Anthem, Pendragon
Tower	chlorotoluron + diflufenican + pendimethalin	250 g/l + 40 g/l + 300 g/l	Tribal

- **Please check** if using an alternative product that it is approved for the crop concerned. Different products with identical formulations do not always have the same approved crops list. This is particularly pertinent to EAMUs
- Inclusion of an alternative product in this list does not represent an endorsement of that product, nor does it imply that products not included in that list are inferior.
- Please check also for levels of active ingredients. Although some of the differences have been highlighted where appropriate, members should still check a.i. levels as differences could clearly lead to different levels of efficacy if used at the same rates recommended in the particular Strategy.

4. Wild-oat and rough-stalked meadow-grass (RSMG) control

Herbicides – Autumn

Autumn herbicide programmes for black-grass or brome control will offer some degree of control of autumn-emerging wild-oats and RSMG.

1. **Wild-oats:** where an autumn programme for control of other grass-weeds is not in place then autumn treatment of wild-oats can be justified **if** the autumn population is high enough to compete with the cereal crop, **or** where resistance is suspected or known to exist, as enhanced metabolic resistant plants may still be controlled if treated when small. If neither of these situations are applicable then treatment can wait until spring when more of the population can be targeted.

- **Avadex Excel 15G or Avadex Factor** can be very effective products if wild-oats are the primary target for autumn treatment, applied pre-emergence, particularly if any resistance to other modes of action is known or suspected to exist. If Avadex is applied, specific post emergence products may not be needed until the spring, however, weed emergence should be monitored and a further treatment should be applied once there are enough wild-oats at the two leaf–early tillering stage.

- Apply post-emergence products when weeds are small (1-3 leaves) in order to maximise control of enhanced metabolic resistant wild-oats. Wild-oats with target site resistance to the mode of action of the 'fops' or 'dens' will not be controlled at any timing by this mode of action.

See below for further descriptions of 'fop' and 'den' product choices.

2. **Rough-stalked meadow-grass:** high populations of RSMG should be controlled in the autumn, either by use of residual herbicides such as **Crystal** or **Liberator** at the more robust end of annual meadow-grass rates – low end of black-grass rates (i.e. **2.0-3.0 l/ha Crystal or 0.3-0.45 l/ha Liberator**).

- Alternatively, **Othello** (0.75-1.0 l/ha) can be used, but only in wheat. Otherwise any of the authorised fops, dims or dens applied at 50-75% of full label rate will give control of RSMG up to the early tillering stage.

- **Auxiliary** (prosulfocarb + clodinafop-propargyl, wheat only) is also a useful product to provide early post-emergence control of both RSMG or wild-/tame-oats. It will also provide some annual meadow-grass and broad-leaved weed control (maximum and recommended dose 3.0 l/ha).

- Again for wheat only, **Broadway Star** is an alternative to ACC-ase products with good activity on wild-oats and RSMG. Note that, like Othello, it has ALS-inhibitor mode of action.

Herbicides – Spring

- **Wild-oats and RSMG**: in wheat, all the available 'fop' and 'den' graminicides (ACC-ase inhibitors, e.g. Axial Pro, Foxtrot, Topik) can give good control of RSMG and susceptible wild-oats, although some are more easily affected by weather conditions than others. These products will work best in warm, humid conditions and when the weeds are still at the tillering stage.

  However, with low–moderate populations of wild-oats, it is often more practical to wait (assuming the product label allows) until the most advanced wild-oat plants are getting towards the end of stem extension before applying herbicide, when they are less likely to 'shake-off' the herbicide through rapid growth, and will also be at or above crop height so less shielded.

- In wheat, **Broadway Star** is an alternative to the ACC-ase inhibitors for **wild-oat** control, provided no other ALS-inhibitor herbicide for grass-weed control has been applied.
  Note: it must be applied before the end of GS32 of the crop.

- In **barley**, **Axial Pro** is the product of choice in the spring for wild-oats.

- Where available, some formulations containing fenoxaprop-P-ethyl also have authorisation for use on barley up to GS31 (e.g. **Foxtrot**). Fenoxaprop formulations that are not authorised for use on barley will kill or severely damage it.
- If using fenoxaprop-P-ethyl on barley, do not tank-mix any other products, including adjuvants and make sure the latest growth stage is not exceeded. (see table opposite)
- It is good practice to monitor emergence patterns of wild-oats. Although this will vary from year to year, it should be possible to know from experience whether the main flushes tend to come in the February–March period or the April–May period.
- Getting enough herbicide onto weeds at different growth stages in amongst a lot of crop foliage is one of the main issues. The other is reduction in susceptibility of the weeds in dry conditions. Using robust doses will help get over the first problem. If conditions are dry, waiting for rain where possible will be worthwhile.
- Depending on wild-oat population levels and staff resources, roguing in early July, especially in wheat, is often a good, cheap way of keeping on top of late germinating oats, or tillers that escape control from autumn applied herbicides.

- **Tame-oats** may not be controlled by some other grass-weed programmes. They are best controlled in the autumn before they become too large. Specific wild-oat herbicides as mentioned above may be needed since control by flufenacet based products, and Atlantis, is variable. It is important to think about the number of ALS-inhibitor herbicides you plan to use, since only one with grass-weed activity can be applied per crop.

Use of ACC-ase inhibitor herbicides (fops and dens) – label restrictions

This mode of action is highly susceptible to the development of resistance to it in grass-weeds. Such resistance is most common in black-grass, but is also becoming more common in wild-oats and Italian rye-grass. To help preserve the activity of such herbicides, a maximum of two products with this mode of action can be used on a crop. If more than one such product is used, the second ACC-ase inhibitor product must contain a different active ingredient to the first product and be used for different target weeds at a different timing.

- Fops = products containing either clodinafop-propargyl (e.g. **Topik**) or fenoxaprop-P-ethyl (e.g. **Foxtrot**)
- Dens = pinoxaden (e.g. **Axial Pro**)

Active ingredients of products listed

Product and MAPP no.	Active ingredients	Concentration	Crops (full label rec.)	Latest Use Crop Growth Stage	Also available as (e.g.)
Auxiliary (14576)	clodinafop-propargyl and prosulfocarb	10 g/l + 800 g/l	WW	Before GS25	–
Axial Pro (19010)	pinoxaden	55 g/l	W & B	Before GS41	–
Avadex Excel (17872)	tri-allate	156 g/kg	W & B	Pre-emergence	–
Avadex Factor (17877)	tri-allate	450 g/l	WW, WB & SB	Pre-emergence	–
Broadway Star (18273)	pyroxsulam + florasulam	70.8 g/kg + 14.2 g/kg	WW, SW, W, rye, triticale	Before GS33	Palio
Crystal (13914)	flufenacet + pendimethalin	60 g/l + 300 g/l	WW, WB	Before 31 Dec or GS23	Trooper, Rock, Shooter
Foxtrot (18808)	fenoxaprop-P-ethyl	69 g/l	W & B	Before GS31 (B); GS39 (W)	Polecat (Wheat only), Oskar
Liberator (15206)	flufenacet + diflufenican	400 g/l + 100 g/l	WW, WB & SW	Before 31 March or GS23/24 (winter crops) by GS14 (SW)	Regatta, Terrane
Othello (16149)	diflufenican + iodosulfuron-methyl + mesosulfuron-methyl	50 g/l + 2.5 g/l + 7.5 g/l	WW	GS31	–
Topik (18568)	clodinafop-propargyl	240 g/l	Wheat, durum, rye, triticale	By GS41 (Wheat) By GS32 (other crops)	Sword, Tuli

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5. Annual meadow-grass and broad-leaved weed control

Where annual meadow-grass and broad-leaved weeds are the targets, the aim should be to get good enough control, especially of meadow-grass, without damaging the crop if on light textured soil and preferably without using an ALS-inhibitor herbicide (unless there is no alternative, such as on organic soils where residual herbicides do not have adequate activity).

Annual meadow-grass (AMG)

1. **Pre-emergence to early post-emergence**

   plus some **broad-leaved weeds:**

   (i) A **flufenacet** product (e.g. **Crystal** or **Liberator**) at **50% dose**,

   (ii) Or flufenacet + picolinafen (e.g. Pontos, Quirinus)

   (iii) Or **Defy 2.0 l/ha** + *either* **pendimethalin (PDM)** 400-800 g/ha or **diflufenican** 25-50 g/ha.

   Straight **flufenacet** is available (see active ingredient table on page 26) but it should always be used with a partner product.

   Crystal, or Defy + PDM are the preferred choices on sandy soils.

   Tower is also a choice. Full dose of 2.0 l/ha delivers 500 g/ha CTU, 600 g/ha PDM and 80 g/ha diflufenican. The low chlorotoluron dose in this product means there are no variety restrictions in wheat or barley.

2. **Post-emergence:** where AMG numbers are high or where, historically, residual herbicides applied pre- or early post-emergence struggle to persist long enough to control later emerging meadow-grass, plan for a (second) herbicide in early spring (up to GS30 of the crop). Additional broad-leaved weed control later can then be planned around whatever these herbicides leave.

   This treatment can be based on choices from products already mentioned above, depending on crop growth stage and calendar date restrictions (see table below) or **pendimethalin** (600-1,000 g a.i./ha) applied up to before crop GS30, ± **diflufenican** (25-50 g/ha).

   PDM + picolinafen products (e.g. **Picona**) can be used as an alternative, particularly where improved control of emerged broad-leaved weeds is required.

   Organic soils: Defy at 3.0-5.0 l/ha, or **Othello** 0.75-1.0 l/ha

Broad-leaved weed control

1. **Non residual, non ALS-inhibitor products**

These are useful products to add to residual treatments to boost control of more difficult or larger broad-leaved weeds. The main option in the autumn is bromoxynil, (e.g. **Maya**). **Maya** can be used to help control groundsel, volunteer OSR and volunteer beans.

Carfentrazone-ethyl (**Aurora**) is also available with particular strengths on cleavers and speedwell.

Another choice, where pansy, speedwells or red-dead-nettle are particular problems, is bifenox (**Fox**).

2. **ALS-inhibitor herbicides**

There are increasing concerns about weed resistance to these types of herbicide. This includes some species of broad-leaved weeds (particularly poppy, but also chickweed and mayweed) as well as grass-weeds. In order to help preserve product efficacy, there are restrictions on the number of ALS-inhibitor products that can be applied to a cereal crop. This is no more than one product if it has grass-weed activity, or no more than two products otherwise. Most products also have calendar date application restrictions. Resistance to florasulam-based products is less common and these can be used (within certain dose and timing restrictions) on a 'two applications count as one' basis. See below or consult product labels for more detail.

ALS-inhibitor herbicides – main options for autumn use

(i) Othello 0.75 – 1.0 l/ha (post-emergence in wheat only). No subsequent use of ALS-inhibitor herbicides with grass-weed activity, limited range of other ALS-inhibitor herbicide sequences.

Strengths – best post-emergence control of meadow-grasses, especially once they have reached the 2-3 leaf stage and the spectrum includes rough-stalked meadow-grass.

(ii) Thor (tribenuron-methyl) can be used at ⅓ label rate in the autumn.

Strengths – helps with post-emergence control of groundsel, cruciferous weeds (e.g. charlock, shepherd's purse, volunteer rape) and chickweed.

(iii) Florasulam products e.g. **Spitfire**, **Slalom**, **Starane XL**, **Lector**, **Zypar**. These products (except **Lector**) are co-formulations of florasulam and either fluroxypyr or Arylex. The maximum total dose of florasulam that can be applied to a crop is 7.5 g/ha; up to half this total (3.75 g/ha) can be applied in the autumn or before 1 February.

- **Spitfire** contains a higher concentration of florasulam than the other co-formulated products, but the same concentration of fluroxypyr (100 g/l). The maximum dose of fluroxypyr that can be applied before 1 February is 150 g/ha. This has the practical consequence that Spitfire can be used at ¾ of its total dose before 1 February, to deliver the maximum allowed before the 1 February dose of florasulam but a lower dose of fluroxypyr than other products. Since florasulam is more active than fluroxypyr at low temperatures and also has a wider weed control spectrum, Spitfire may offer more cost effective control.

  Strengths – robust control and rapid speed of kill on brassica weeds, chickweed, cleavers and volunteer beans.

- **Zypar** (florasulam and Arylex (halauxifen-methyl)) is commonly used in spring having relatively good activity in cooler conditions, but it can be used in autumn (from 15 September).

  Strengths – has a wide spectrum of activity including volunteer beans and brassica weeds (at 0.6 l/ha) as well as activity against some umbellliferous weeds (when small) at 0.75 l/ha.

- **Lector** and other straight florasulam products (see below) offer growers greater flexibility in herbicide options compared to the co-formulations where they are available.

  Strengths – same as for Thor, plus cleaver and volunteer bean activity.

  The other key advantage is that two florasulam-containing products can be applied (one in the autumn and one after 1 February) to a crop. Using florasulam in this way still only counts as **one** ALS-inhibitor product for broad-leaved weed control, therefore there is still an option to apply another ALS-inhibitor product for broad-leaved weed control (such as metsulfuron-methyl) should there be a need.

Active ingredients of products listed

Product	Active ingredients	Concentration	Crops and Latest Use (Crop GS)	Also available as (e.g.)
Aurora	carfentrazone-ethyl	500 g/kg	All cereals except rye to before GS33	–
Crystal	flufenacet + pendimethalin	60 g/l + 300 g/l	WW, WB GS23 or end of December	Trooper, Shooter
Defy	prosulfocarb	800 g/l	WW, WB GS21 EAMUs durum wheat, rye, Sp barley, triticale	Fidox, Fade
Fox	bifenox	480 g/l	W, WB, W rye, W triticale to before GS32	–
Hurricane	diflufenican	500 g/l	W, B, to before GS32, durum wheat to end of February + EAMU oats. Rye, triticale, to before GS13	Twister, Sempra
Lector	florasulam	50 g/l	All cereals (not durum wheat). ½ rate up to end of January.	Paramount, Solstice
Liberator	flufenacet + diflufenican	400 g/l + 100 g/l	WW, WB GS23,+ by end of March (0.3 l/ha), Sp W. to GS14 Also various EAMUs for other cereals	Herold (400 g/l + 200 g/l), Regatta, Firestorm, Terrane Winter triticale and rye label use for some products
Maya	bromoxynil	402 g/l	Wheat, barley, oats to before GS32	Buctril (225 g/l to GS29, + also on rye + triticale)
Omaha 2	diflufenican + pendimethalin	40 g/l + 400 g/l	Wheat, barley, winter rye, triticale to GS30 W + B, to GS14 w rye, triticale (not pre-em after 20 November)	–
Othello	diflufenican + iodosulfuron-methyl + mesosulfuron-methyl	50 g/l + 2.5 g/l + 7.5 g/l	WW, before GS32	–
Picona	picolinafen + pendimethalin	16 g/l + 320 g/l	W, B, triticale, rye to before GS30	PicoPro, PicoMax
Pontos	flufenacet + picolinafen	240 g/l + 100 g/l	WW, WB, rye, triticale to before GS30	Quirinus (240 g/l +50 g/l)
Spitfire	florasulam + fluroxypyr	5 g/l + 100 g/l	All cereals (not durum wheat). ½ rate up to end of January.	Starane XL, Hunter, Cleave (a.i. 2.5 g + 100 g)
Stomp Aqua	pendimethalin	455 g/l	WW, WB, durum wheat, W rye, triticale, to before GS30. Sp barley (pre-em)	Anthem (400 g/l), Claymore (400 g/l)

System 50	flufenacet	500 g/l	WW, WB Apply before GS23/31 December	Firecloud, Starfire
Thor	tribenuron-methyl	500 g/kg	All cereals. To GS39. Up to 10 g/ha before end of February.	–
Tower	chlorotoluron, diflufenican, pendimethalin	250 g/l + 40 g/l + 300 g/l	Wheat, barley, W rye, W triticale pre-em up to before GS30.	Tribal
Zypar	florasulam + halauxifen-methyl	5 g/l + 6.25 g/l	Wheat, barley, W rye, W triticale	–

- **Please check** ii using an alternative product that it is approved for the crop concerned. Different products with identical formulations do not always have the same approved crops list. This is particularly pertinent to EAMUs.
- Inclusion of an alternative product in this list does not represent an endorsement of that product, nor does it imply that products not included in that list are inferior.
- Please check also for levels of active ingredients. Although some of the differences have been highlighted where appropriate, members should still check a.i. levels as differences could clearly lead to different levels of efficacy if used at the same product rates recommended in the particular Strategy.

6. Weed control in winter oats

Herbicides

Grass-weed control programme:

- **Liberator** 0.3-0.45 l/ha pre-emergence

The lower dose is sufficient for broad-leaved weeds and meadow-grasses. Other grass-weeds would require the higher dose.

Oats are sensitive to pre-emergence treatment which has, in some of our trials, caused crop damage and even plant death, so be prepared for this if such treatments are used. This is particularly so with the higher dose above, but Liberator is the only grass-weed option for this crop and this level of input will be needed for the more difficult grass-weeds. We have looked at low doses of Liberator, topped up with extra flufenacet: this approach did not show the crop effects seen with higher Liberator doses, however there are now no straight flufenacet products with approval for oats.

Broad-leaved weeds

- **Tribenuron-methyl** (e.g. Thor) will control a range of broad-leaved weeds and can be applied in autumn from the three leaf stage of the crop.
- Spitfire is a florasulam-based product with approval for oats, having a good spectrum of broad-leaved weed activity. Spitfire can be applied in autumn (similar products such as Cleave from spring onwards).
- Hurricane (diflufenican) has an EAMU for winter oats. However, NIAB TAG trials have shown that any crop damage from Liberator (see above) is more down to the diflufenican than flufenacet, so again growers should be conservative with dose if using Hurricane or similar.
- Other broad-leaved weed options centre on **spring-applied** products such as sulfonylureas, HBNs and fluroxypyr. These are frequently sufficient, particularly where grass-weeds are not a problem and autumn weed germinations are light, as an actively competing oat crop can effectively suppress low weed populations.

- The list of herbicide options for this crop continues to shorten. Assuming reasonable establishment, the vigorous competitive growth offered by oats will contribute to the control of both broad-leaved and grass-weeds (including black-grass). However, do not grow oats where grass-weed populations (other than annual meadow-grass) and/or levels of resistance, are high.

Active ingredients of products listed

Product	Active ingredients	Concentration	Example products
Hurricane	diflufenican	500 g/l	(none with oat EAMU)
Liberator	flufenacet + diflufenican	400 g/l + 100 g/l	Regatta
Spitfire	florasulam + fluroxypyr	5 g/l + 100 g/l	Hunter
Thor	tribenuron-methyl	500 g/kg	Taxi

- **Please check** if using an alternative product that it is approved for the crop concerned. Different products with identical formulations do not always have the same approved crops list. This is particularly pertinent to EAMUs.
- Inclusion of an alternative product in this list does not represent an endorsement of that product, nor does it imply that products not included in that list are inferior.
- Please check also for levels of active ingredients. Although some of the differences have been highlighted where appropriate, members should still check a.i. levels as differences could clearly lead to different levels of efficacy if used at the same rates recommended in the particular Strategy.
- For all EAMUs (e.g. Hurricane, Liberator) remember to obtain a copy of the EAMU before using the product. Use of products under an EAMU is at grower's risk, and in particular care should be taken when considering a tank-mix that includes any product with an EAMU.

7. Slug control

- **Pre-drilling**

Initial cultivation: any amount of soil surface disturbance will help destroy eggs before they hatch, even if only a straw rake is used. The more comprehensive the cultivation is, the more effective such control tends to be. Ploughing will bury surface populations out of the way of sown seeds, but may not actually kill as many slug eggs and if soil is not re-consolidated, buried populations can return to the zone of sowing quite quickly if conditions for slug activity are suitable.

Seedbed preparation: creating a fine firm consolidated seedbed will significantly reduce damage, or at least be less conducive to slug movement. With modern drills able to produce such a seedbed more easily and on a wider range of soil conditions than used to be the case, there may be less reliance on rolling as a separate operation. However, where conditions allow, rolling after drilling should still be considered, if it will further consolidate the soil without leaving it vulnerable to capping or similar problems. Having fine tilth around the seed will also significantly reduce the ability of slugs to hollow out the seed before it germinates.

For cereals, drill deep, (40-50 mm) or certainly don't be tempted to drill shallow, inevitably it is the shallow-drilled seed that sees the greater degree of seed hollowing.

- **Slug pellet application**

All of the following guidelines assume use of ferric phosphate products. Metaldehyde is still approved for use (and at the time of writing, the ban has been overturned though this may change again and product sources may be restricted anyway) but if using this it is important to assess the risk of water contamination and follow the Metaldehyde Stewardship Group guidelines (see below). Do not use metaldehyde if there is any risk of water contamination.

In all cases test bait or check for obvious damage first. Do not treat prophylactically.

Very high risk situations

1. In high risk situations (e.g. direct drilled crops after oilseed rape with damp straw or chaff residues), slug activity may be seen on crop volunteers. Use of a low dose of pellets soon after drilling may be advisable.
2. Pelleting prior to sowing is another option in particularly high risk situations.
3. Monitoring should then be used to assess if further treatment is needed.

High – moderate risk situations

For example, crops after oilseed rape established by one pass cultivation techniques:

1. Consider the need for a low dose of pellets after sowing as in point 1 above.
2. If a very early application is not required, use as low a dose of pellets as possible for the main application if risk monitoring shows it to be necessary. Do not use slug pellets as bait if traps are used (see notes on Test Baiting below).

Medium – low risk situations

For example, second cereals or other crops drilled into a good seedbed following ploughing. Monitor for slug activity and only apply pellets as or when risk monitoring and test baiting shows it to be necessary.

- Once crops get to the 3-5 leaf stage, further treatment is only justified if the crop is set back by an intense period of severe grazing.
- It is important to establish a hierarchy for the slug risk in different fields across the farm, allowing more targeted use of slug pellets to where they are likely to be most needed (see risk assessment table below).

Table 2. Assessing the likely need for slug pellets in cereals

Factor	Risk of slugs
Damp conditions during/post harvest	**
Dry conditions during/post harvest	–
Soil has > 40% clay	***
Soil has < 20% clay	–
Field has a history of slug problems	***
Winter oilseed rape as previous crop	****
Direct drilled	****
Cultivations (reduce by one star per cultivation pass, or by two stars if using a multi-cultivation train pass)	***
Straw incorporated	*
Straw baled	–
Consolidated seedbed with seed in tilth	–
Open seedbed with variable tilth	***
September sown	*
October sown	**
November sown	*
December sown	–
TOTAL	

12 stars or more – slug risk very high, monitor fields closely (2-3 times a week)
9 stars or more – slug risk high, monitor regularly (1-2 times a week)
6 stars or more – slug risk moderate, monitor fields once a week
3 stars or more – slug risk low, but possible, monitor fields once a week
< 3 stars – slug risk low, slugs not likely to be a problem.

- Broadcasting pellets will only kill slugs if they are actively feeding on the soil surface. It is generally thought only 5% of the population is above ground at any one time, which unless conditions are particularly conducive, means 95% is still below ground and away from the effects of the pellets. Active surface feeding is most likely when the soil surface is moist and conditions are humid with mild nights.
- Often the worst damage occurs where there are high numbers of slugs (which can often be very small, newly hatched ones) at the time of crop germination or emergence. In these situations, the number of bait points can be important. Aim for at least 40 pellets /m^2.
- Ferric phosphate acts as a stomach poison and slugs tend to die underground, lack of crop damage rather than easily visible dead slugs is therefore the main indicator of success.
- The most effective ferric phosphate products will contain around 3% ferric phosphate.
- Growers who still wish to use metaldehyde anywhere are best to use it at as low a dose as possible for the first treatment on earlier sown crops, because it is known that most of the metaldehyde (85%+) in water supplies reaches the water courses through field drains. Good practice can minimise losses to the environment at application, but once applied, the fate of active ingredient is in the hands of the weather. Products containing the lowest percentage active ingredient (1.5% or 3%) should therefore be used.
- Avoid using metaldehyde if drain flow is likely to start soon.

Test baiting

- If slug activity is not obvious, test bait with a handful of chicken layers' mash or similar (not slug pellets), placed under a tile in susceptible parts of the field. Inspect for slugs every few days, to show when slugs are active. Thresholds for these traps would be roughly four or more slugs per trap for wheat and one per trap for OSR prior to cultivations. (Moving soil in any way, in particular ploughing, will check slug activity so test-baiting soon afterwards could underestimate the true population that may recover later.)

Slug pellets – use

- Operators applying slug pellets should hold a PA4S certificate or a pre-June 1994 PA2 or PA3 certificate. If relying on a pre-1994 certificate, demonstration of more recent training will also often be required. See also Qualifications required by Operators section of The Metaldehyde Stewardship Group Website: **www.getpelletwise.co.uk** for further details. This website also has settings and calibration information for a range of slug pellet application machinery.
- For pellet application training, see the NPTC City & Guilds (**www.nroso.org.uk**).

Metaldehyde Stewardship Group (MSG) guidelines

- Use minimum active per hectare to avoid drainage and run-off losses
- Maximum application rate 210 g metaldehyde a.s/ha*. For additional protection of water, suppliers/BASIS advisors may recommend rates reduced to 160 g a.s./ha or less*
- Maximum total dose from 1 August to 31 December: 210 g metaldehyde a.s./ha*. For additional protection of water, suppliers/BASIS advisers may recommend rates reduced to 160 g a.s/ha or less*
- Maximum total dose: 700 g metaldehyde a.s./ha/calendar year*
- No pellets to be applied within ten metres of a watercourse
- Do not apply when heavy rain is forecast
- If drains are flowing do not apply metaldehyde-based slug pellets.

*from any combination of metaldehyde products. 700 g is also the statutory limit.

a.s.: active substance (or active ingredient)

8. Autumn pest control – aphids and other pests

Insecticides

Aphids (BYDV)

- Aphids can introduce BYDV into cereal crops and need to be controlled from emergence until mid November, when they usually cease moving into crops, though in extended mild autumns (see below) activity can continue beyond this. Protection can only be achieved now with foliar sprays, the number of treatments depending on the length of protection required, itself determined by sowing date. Crops sown at the end of October should not need any treatment, those sown mid-October will only need one spray. Crops sown earlier than this may need more than one spray and it is for these that the T-sum system (see below) is particularly important.

- Pyrethroids are the only insecticide option for bird cherry aphid control. Resistance development therefore has to be considered. Resistance is already building in the grain aphid (also a virus vector) and so these may not be controlled by pyrethroids.

  Irrespective of geography, topography or latitude all parts of the UK are at risk from colonisation by virus-carrying aphids. The level of risk therefore is almost entirely down to sowing date and hence the period of protection required.

- Pyrethroids can be short-lived in and on the plant, depending on environmental conditions. Repeating treatments according to when the previous one ran out would lead to excessive treatment. It is far better to apply according to the generation time of the aphids, i.e. when any survivors from the previous treatment have produced a new generation of aphids. This can be determined by the aphid T-sum method, details are available from AHDB and other sources.

  The time period for each generation has been calculated as 170 day degrees (known as 170 DD). This is the average 24 hour temperature minus 3 degrees accumulated over a number of days until a total of 170 is reached. Depending where you are, this is currently 17-23 days from crop emergence assuming no previous treatment.

  Current advice suggests that the 170 DD is the point to start to spray a crop with a foliar insecticide such as a pyrethroid. These sprays are largely contact, knock-down materials with very little inherent active persistence. As a result, if you spray too early, you will kill some adults before they produce young but others will still reproduce large numbers and if you spray significantly late, economic BYDV infection may have already occurred.

  The AHDB, among others, provide a BYDV risk monitoring tool that growers can use based around this 170 DD figure. This calculates risk using data from a nearby weather station coupled with a manually entered 'risk start date'. Access this at https://cereals.ahdb.org.uk/bydv

  The start day is either crop emergence or the date the crop was last sprayed with a foliar insecticide.

  The risk from aphids and BYDV declines into November and December and any crop emerging after the first week of November is unlikely to be at any risk of infection, and hence would not require any treatment.

Other pests

Gout fly

- This is mainly a pest of early September (or earlier) sown crops. It can also be found in crops sown around mid-September but usually the intensity of infestation is too low to affect the yield. Many crops that suffer high levels of infestation, but after the 2-3 leaf stage, do not ultimately suffer significant yield loss. If the winter is relatively mild the crop can grow and recover. If a cold winter follows however, recovery may not be adequate and yield losses can occur.
- The presence of gout fly is indicated by small (1-2 mm) cigar-shaped white eggs on leaves. If eggs are found on more than 50% of plants at the 1-3 leaf stage, control should be considered.
- Where control is needed, a pyrethroid sprayed within a few days of enough eggs being seen, will provide adequate control. But their use for gout fly control should be minimised as this will increase the selection of aphid resistance as noted above. Ultimately, BYDV can be a much larger robber of yield than gout fly damage.

Wireworm

- Austral Plus or Signal seed treatments are the only available chemical control now for high risk situations.

Wheat bulb fly

- High-risk crops should be treated with **Austral Plus** (tefluthrin + fludioxinil) or **Signal** (cypermethrin) seed treatment – these are now the only reasonably effective options. Austral Plus also has a fungicide element for seed-borne disease control, a separate fungicide seed dressing will need to be co-applied if using Signal and also wanting seed-borne disease control. Note 'high risk crops' assumes these are late sown; lower risk, earlier sown crops (mid-October or earlier) are unlikely to get sufficient protection from these products.
- The seed treatments work best where the seed is drilled no deeper than 4 cm. If drilled deeper the larvae can enter the wheat shoot above the zone of protection provided by the seed treatment. Planting seed at less than 2.5 cm may also reduce the level of control.

Frit fly and leatherjacket control

- Currently there are no insecticide treatments authorised for control of these pests, so growers need to be mindful of any potential risk and employ cultural control methods accordingly.
- For frit fly, ensuring there is a period of between four and six weeks between grass ley destruction and subsequent cereal sowing should mean the majority of larvae migrating from the dying grass starve to death or are eaten before providing the new cereal crop to them as an alternative food source.
- Frit fly prefer to lay eggs in rye-grass rich leys and often growers will know if they have a history of damage on the farm or not.
- Leatherjackets cannot be got rid of quite so easily. There are several species, but the most common types that are pests in agriculture tend to emerge as adults in September – early October. They lay eggs in grassland and then die. The larvae hatch and grow slowly over several months. They will eat both live and rotting vegetation, so often do not start to damage crops following grass until late winter – early spring.
- Dry weather in early autumn desiccates newly-hatching larvae and can reduce the seasonal risk significantly. In wetter autumns, survival is likely to be much better and therefore the risk of crop damage will also be higher.
- The most effective method of control is to time grassland destruction so that suitable areas for adults to lay eggs are not present. This effectively means destroying grassland by mid-late August prior to sowing autumn cereals. Making sure grassland is either dead or well buried by this time will further dissuade egg-laying adults.

9. Winter beans – establishment and seed rates

Time of drilling:

- **Mid-late October**. Traditionally beans are sown when the wheat drilling is complete, though where the latter is delayed for weed, disease and/or aphid management then some juggling will be necessary. Drilling into early November can be as successful in the far south but elsewhere yields will start to decline, whilst mid-October would be the target for the north.

Target populations:

- **Drilled crops:** aim for **18-20 plants/m²** for crops drilled in October. If drilling is delayed until December/January then move towards target plant numbers of **30-40 plants/m²**.
- **Seed broadcast and ploughed-in:** aim for **25 plants/m²**.

$$\text{Seed rate (kg/ha)} = \frac{\text{thousand grain weight x target plant population}}{\text{\% germination}} \times \frac{100}{100 - \text{field loss}}$$

Check your individual seed batches as actual TGW, between varieties especially, can vary significantly.

Cultivation	Spring target plant population	Expected field losses (%)
Plough	25	15+
Subsoiler Drill	18	10-15
Direct Drill	18	5-10

Example: $\frac{600g \times 20}{80} \times \frac{100}{100-10} =$ **167 kg/ha**

Seed testing and treatments

Seed treatments are not generally required, but home-saved seed should be tested for ascochyta and stem nematode. It is also a good idea to check if purchased seed has been tested for these problems as there is no statutory requirement for such tests.

Time of drilling

The optimum time of drilling is **mid-late October**.

Time of drilling should aim to have the crop sufficiently well established (first leaves unfolded) before the onset of winter. If too forward the crop could suffer stem damage (e.g. from wind damage through the winter period), as well as producing too much vegetative growth in the spring, increasing the lodging risk and disease pressure.

Winter beans do not have a vernalisation requirement and can be sown in spring, however later sown crops are slow to establish and produce open canopies which are late to harvest.

Flexibility around the optimum sowing date will depend on:

- **Location:** generally the further south and west and the milder the climate the greater the ability to extend into early November if necessary without significant yield loss. Topography will also influence the decision, both height above sea level and north-facing slopes will retard growth, and hence dictate a shorter drilling window.
- **Soil type:** the lighter and more free draining soils are slower to cool in the autumn and warm up more quickly in the spring. Hence they have a greater degree of flexibility in extending the drilling window in the autumn. On the lightest soils the third week in October might be the optimum in a normal year.

Conversely on heavy colder soils early October might be more appropriate, thought this will conflict with drilling wheat, which will always take priority at this time of the year.

- Recent trials have shown variable responses to sowing dates. With no limiting factors, the higher yields have come from earlier sowings but often these crops suffer intense disease pressure and/or excessive growth and hence lodging, which compromises yield. In 2016 at Cambridge, high disease pressure produced the lowest yields in a September-sown crop.
- **Weed control:** for beans this relies heavily on pre-emergence options so whatever sowing date is selected, make sure it is also possible to apply a residual herbicide around the same time.

Seed rates and target plant populations

- Optimm yields can be produced over a wide range of plant populations. Higher populations produce thicker crops which will compete with weeds better, but pod set is often inversely proportional to plant population, so more plants does not necessarily mean more yield.

  The trend from our trials is that sowing date has a bigger influence on canopy size, crop height and lodging than plant population. So when sowing late, it is generally a good idea to increase seed rate.
- Although higher plant populations will increase the potential for lodging, with good standing power varieties like Wizard and Honey, this may be less of a problem than it used to be.
- Excessively thick crops, which may result from early sowing, will also increase the susceptibility to chocolate spot, particularly combined with early drilling.

10. Winter beans – weed control

Almost all herbicide options for this crop are pre-emergence so growers must be prepared to spray soon after drilling. One of the key actives for grass-weed control, propyzamide, must be applied within seven days of sowing.

Grass-weeds

- Mixes of **pendimethalin** and **prosulfocarb** will provide general broad spectrum weed control, including some control of grass-weeds.

  Defy 2.0-3.0 l/ha + **pendimethalin** 800-1,000 g/ha a.i.

- For stronger **black-grass** control, programmes based on **propyzamide** and **carbetamide** should be used (as an autumn/spring sequence or possibly mixed with either or both of the above). Propyzamide must be applied within seven days of sowing, carbetamide can be applied post-emergence up to the end of February.

- Use of these products will reduce reliance on graminicide (ACC-ase inhibitor) herbicides. Most populations of black-grass are resistant to this mode of action.

- Such ACC-ase inhibitor products (Laser, Falcon, Panarex etc) may give grass-weed control depending on the resistance status. As these products are often used elsewhere in the rotation, they should only be used as follow-up to residual herbicides if needed.

Broad-leaved weeds

- The above products and programmes will give a good level of broad-leaved weed control. Further options involve some **clomazone** products (again, **pre-emergence**) but note some have 10 m buffer zone requirements.

- **Nirvana** (pre-emergence only) contains imazamox and pendimethalin and the latter would provide some grass-weed control (e.g. meadow-grasses) if the full dose (4.5 l/ha) were used.

- Beans are an open crop that will potentially allow weeds to establish over a long period of time. However they traditionally allow some cultural control, being later drilled than most other winter crops.

- As with other crops, a good quality seedbed is necessary for good performance from residual herbicides.

- Sowings from late October onwards should require a less robust pre-emergence herbicide input than early October sowings. Cooler soil temperatures will help herbicides persist longer and the amount of weed germination and vigour of weeds will usually also be significantly less. On the other hand propyzamide, for example, which must be applied soon after sowing, will not persist as long if applied to, say, early October sowings.

- If prosulfocarb and pendimethalin are heavily relied upon in other parts of the rotation, then clomazone-based programmes will provide a break from this chemistry. This will be helpful in the medium to longer term in preserving herbicide efficacy.

- Glyphosate can be applied pre- and/or post-sowing, possibly mixed with a pre-emergence residual herbicide if compatibility allows.

  There are however now increasing concerns about weeds potentially developing resistance to glyphosate. The Weed Resistance Action Group (WRAG) has recently published guidance aimed at reducing the risk of this happening. Application prior to crop sowing without adequate follow up measures to control any surviving weeds is considered to be one of the higher risk practices.

  Therefore, if doing this: first check that this timing is on the product label for the glyphosate you are using, use a robust rate of glyphosate (540-720 g a.i./ha); then use a herbicide programme with different modes of action to glyphosate, that will effectively control surviving black-grass and rye-grass in particular. (Note the maximum dose post-drilling, pre-emergence is 540 g a.i./ha).

  Bentazone (Basagran etc.) can be applied from the two-leaf pair stage but works better in good conditions in spring and can be used to clean up any left-over weeds from other programmes, as necessary.

Table 2. Main herbicide options for winter field beans

Active ingredients	Example products	Application timing	Comments
propyzamide	Kerb Flo 500, Flomide, Cohort	Pre-em	Strongest individual option for residual black-grass control with some broad-leaved weed control, but addition of pendimethalin or clomazone needed for a better broad-leaved weed spectrum. Three-way mixes with prosulfocarb and pendimethalin are particularly effective.
carbetamide	Crawler	Pre or post-em November to end of Feb.	Less persistent than propyzamide, but is the only residual with post-em use option, so is a very useful follow-up product, especially for black-grass control if needed.
pendimethalin	Anthem, Claymore	Pre-em	Various products, all with **just EAMU** authorisation on winter beans.
prosulfocarb	Defy, Jade	Pre-em	**EAMU** authorisation (N.B not all products). Good weed spectrum including cleavers, vol OSR and crane's bill, but weaker on mayweed.
imazamox + pendimethalin	Nirvana	Pre-em	Good weed spectrum. Only available label authorisation for the use of pendimethalin. Imazamox is an ALS-inhibitor mode of action.
clomazone	Centium 360 CS	Pre-em	Note that some products have significant field margin buffer zone requirements.
bentazone	Basagran SG	Post-em from 2 leaf-7 leaf pairs	Best used only if necessary in the spring to tidy up broad-leaved weeds.
Foliar grass-weed control (ACC-ase inhibitors)			
fluazifop-P-butyl	Fusilade Max	2 leaf pairs – before flower buds visible	Useful on volunteer cereals and bromes.
propaquizafop	Falcon, Shogun	Post-em – before flower buds visible	Useful on volunteer cereals and bromes.
quizalofop-P-ethyl	Leopard 5 EC	Post-em – 8 weeks to harvest	Useful for volunteer cereal control.
quizalofop-P-tefuryl	Panarex	Post-em – Flower buds visible	Useful for volunteer cereal control. Can only be applied in the spring.
cycloxydim	Laser	Post-em – 8 weeks to harvest	Good on bromes and rye-grass where these are not fop/dim resistant.

1. Clomazone – temporary crop bleaching may occur following application.
2. Bentazone, propyzamide and carbetamide are all particularly common problem pesticides that occur in water. Follow best practice guidance to avoid water pollution. See **www.voluntaryinitiative.org.uk** for further details.
3. ACC-ase inhibitors are particularly prone to control of black-grass being compromised due to weed resistance. An ACC-ase active ingredient can only be applied once to a crop. If a second ACC-ase product is required, it must contain a different active and be applied to different target weeds at a different timing.
4. EAMU authorisation = Extension of Authorisation for Minor Use. Use is at grower's risk and the user must have a copy of the relevant EAMU document before use. These are available to download from **https://secure.pesticides.gov.uk/offlabels/search.asp**

NIAB is a leading UK centre for plant science, crop evaluation and agronomy, with headquarters in Cambridge and regional offices across the country. NIAB spans the crop development pipeline, combining within a single resource the specialist knowledge, skills and facilities required to support the improvement of agricultural and horticultural crop varieties, to evaluate their performance and quality, and to ensure these advances are transferred into on-farm practice through efficient agronomy.

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To enquire about NIAB membership services, contact:

NIAB
Huntingdon Road
Cambridge CB3 0LE
Tel: +44 (0)1223 342200
Fax: +44 (0)1223 277602
info@niab.com